8. THE COLONIZATION OF RUDERAL BIOTOPES IN THE CITY OF BERLIN BY ARTHROPODS

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SUMMARY

In three ruderal sites with varying degrees of isolation selected groups of arthropods have been investigated: oribatid mites, carabid beetles, hover flies and bumble bees. These sites have been colonized in the last 3 decades. In contrast to one small and isolated plot the areas adjacent to a large park and other ruderal places are species-rich. The results are discussed in relation to 'island' biogeography.

INTRODUCTION

In the heavily built-up centres of large European cities land areas that are not used by man are rare, usually very small and short-lived. In Berlin, however, a few cleared rubble sites have remained unused for some years and, in some cases, for decades after the war. These sites have made a characteristic succession of ruderal vegetation and fauna possible. The typical vegetation succession up to the present day has led in a few places to the development of a young forest; more often, however, it has resulted in special dry grassland communities and stands of herbaceous plants (Blume *et al.* 1979).

The distribution of such ruderal areas is usually in the form of islands and results in special demands on the fauna. Animal colonization of such vegetation islands depends on the dispersal power of the animals, the proximity to areas already colonized and on the ecological conditions of the habitat. Beyond the typical abiotic habitats, factors in the city, such as relatively high values of temperature, dryness, air pollution and eutrophication of the soil, the constant detrimental influence of man must be tolerated, for example the frequent surface destruction of the soil, refuse-tipping and the introduction of various pollutants.

In this paper, four animal groups will be studied with respect to their colonization capability on three ruderal sites in Berlin:

1. *Oribatid mites*, as an example of small soil arthropods, important plant decomposers, with a generally passive dispersal.

2. *Carabid beetles*, as an example of predatory arthropods of the soil surface which walk more than fly and are in part even incapable of flying.
3. *Hover flies*, as an example of flower-visiting insects with a wide dispersal power.
4. *Bumble bees*, as an example of specialized flower-visitors with a limited range in the vicinity of the nest.

THE STUDY SITES

The areas studied are situated in the built-up centre of Berlin, in varying degrees of isolation. They have all developed in the course of 20–30 years from bare-ground sites to relatively similar ruderal plots with grass or tall herb communities containing some woody plants. The soils are pararendzina on rubble.

Site I

An isolated ruderal plot in the heavily built-up city centre (the corner of Fasanenstrasse and Lietzenburger Strasse) of approximately 0.2 ha, protected from visitors by a high fence. The distance to the next large park (the Zoological Garden) is approximately 1 km. The vegetation is a tall herb plant stand which is subject to great anthropogenic disturbance and which had been mown shortly before this study. A few woody and climbing plants are found on the fringe.

Site II

A ruderal site at Lützowplatz in the city centre, approximately 0.8 ha. This site was levelled rubble in 1959, and has been spontaneously colonized by wild plants. It is separated from the very large park 'Grosser Tiergarten' to the north by only 500 m; in between lie vacant lots and a canal. It is surrounded by buildings in the other directions. Area IIa is a young forest of *Robinia* (Chelidonio-Robinietum). Area IIb is a ruderal grassland site with a few patches of tall herbaceous plants.

Site III

A ruderal area on the Tiergartenstrasse, directly adjacent to the 'Grosser Tiergarten'. The area studied is approximately 1 ha, and borders on other ruderal areas and ruins. The vegetation is a mosaic of grassland, tall herbaceous plants and shrubs.

ORIBATID MITES (ACARI, ORIBATEI)

On each site 10 soil samples of 100 cm^3 volume were taken at a depth of 0–4 cm and the fauna extracted with a Berlese-Tullgren apparatus. In total 20 species of oribatid mites occur in the three sites.

Site I, which is the most isolated, is the poorest in species and individuals (Table 8.1). All species found are either drought-tolerant ubiquists or drought-loving species.

TABLE 8.1. *Oribatid mites (Dominance %) in three ruderal areas in the city of Berlin.*

Site	I	IIa	IIb	III
Eupelops occultus (Koch)				7
Liochthonius lapponicus (Träg.)			22	
Oppia minus (Paoli)			9	
Oppiella nova (Oudms.)			1	
O.obsoleta (Paoli)	6			
Oribatella quadricornuta (Mich.)		+	+	
Oribatula tibialis (Nic.)	26	7		
Peloptulus phaenotus (Koch)			+	2
Pilogalumna allifera (Oudms.)		5		5
P.tenuiclava (Berl.)				13
Quadroppia quadricarinata (Mich.)				2
Rhysotritia ardua (Koch)		1	5	1
Scheloribates laevigatus (Koch)				21
Scutovertex minutus (Koch)				+
Steganacarus striculus (Koch)		+		
Suctobelbella nasalis (Forss.)		2		
S.sarekensis (Forss.)	68	17	3	5
S.subcornigera (Forss.)		51	7	8
Tectocepheus sarekensis Träg.		16	51	36
Trichoribates novus Selln.			2	+
Species:	3	9	10	12
Individuals in one l (0–4 cm)	31	184	283	259

The oribatid fauna of the ruderal Sites II and III is, in comparison to that of cultivated park lawns, abundant, but in comparison to that of city forest soils, however, less well-developed (Weigmann & Stratil 1979). Typical forest species are insignificant, even on Site IIa. The colonization of the sites by moss mites and other small arthropods has not been completed and, because of the purely passive dispersal of mites, a balanced, species-rich ruderal fauna will only be observed after a long period of time. Site I is, because of its isolated position from sources of mites, still in the pioneer-colonizer phase with respect to the oribatid mite fauna. The most frequent species in the dry city soils in Berlin, *Tectocepheus sarekensis*, is missing there.

CARABID BEETLES (COLEOPTERA, CARABIDAE)

The carabid fauna as analysed with the help of three pitfall traps per study site, each of which was emptied weekly during the vegetation-growing season from May until October (the total catch was 1,040 carabids). The results in Table 8.2 do not include those species represented by only one individual per site. Thirty-seven species of carabids were found.

TABLE 8.2. *Carabid beetles (Dominance %) in three ruderal areas in the city of Berlin.*

Site	I	IIa	IIb	III	wings
Amara aenea (Deg.)		1	1	9	m
A.bifrons (Gyll.)	12	2	1	6	m
A.consularis (Dft.)		+		1	m
A.fulva (Müll.)		2			m
Badister bipustulatus (F.)		+	2	+	m
Bembidion lampros (Hbst.)		1			d
Calathus ambiguus (Pay.)		1		2	m
C.fuscipes (Goeze)		23	46	11	b
C.melanocephalus (L.)	27	5	14	4	d
C.mollis (Marsh.)	12	1	1	+	d
C.piceus (Marsh.)	46				d
Harpalus aeneus (F.)		1	1		m
H.rubripes (Dft.)		+	2	1	m
H.rufipes (Deg.)		19	3	1	m
H.smaragdinus (Dft.)		1		1	m
H.tardus (Panz.)		1	2	2	m
H.vernalis (Dft.)			3	2	b
H.winkleri Schaub.		1			m
Licinus depressus (Pay.)				1	b
Masoreus wetterhalli (Gyll.)				1	d
Metabletus foveolatus (Fourc.)			1	2	b
Nebria brevicollis (F.)		38	24	50	m
Synuchus nivalis (Panz.)				+	d
Species, total:	7	24	15	26	
Individuals/one trap, 30 days	4.7	31.3	11.4	36.6	

Rare species are omitted. Wings: m = macropterous; b = brachypterous; d = dimorphic species.

The carabid fauna is composed for the most part of widespread species of dry grass, fallow land and cultivated fields (Thiele 1977; Haeck 1971; Barndt 1976) and differs essentially from the forest carabid fauna in parks (Schaefer & Kock 1979), only one forest species (*Nebria brevicollis*) is abundant. The carabid fauna of Site IIa is not a forest one. Of the brachypterous species (*Calathus fuscipes*, *Harpalus vernalis* and *Metabletus foveolatus*), only *Calathus fuscipes* is frequent at Sites II and III. Of the species which, according

to the literature, are dimorphic (i.e. part macropterous (m) and part brachypterous (b)), the following were found: *Bembidion lampros* (100% m), *Calathus melanocephalus* (6% m), *C.mollis* (64% m), *C.piceus* (100% m), *Masoreus wetterhalli* (75% m) and *Synuchus nivalis* (100% m).

The isolated Site I is poor in species (7) and in individuals (Table 8.2); the ruderal meadow of Site III is, with 26 species, as well colonized as dry grassland areas outside the Berlin city region (Barndt 1976). Site IIb (ruderal meadow) is poorer in species than IIa, but has the same dominants with the exception of *Harpalus rufipes*.

HOVER FLIES (DIPTERA, SYRPHIDAE)

The syrphid fauna has not been studied quantitatively. The total species inventory (25 spp) was established by net catches made on 10 catch dates in two summer periods.

The fauna (Table 8.3) consists of generally widespread species. In much

TABLE 8.3. *Hover flies in three ruderal areas in the city of Berlin.*

Site	I	II	III
Chilosia sp.		x	
Chrysotoxum festivum (L.)			r
Epistrophe balteata (Deg.)	x	xx	xx
Eristalis arbustorum (L.)		xx	xx
E.intricarius (L.)		xx	x
E.pertinax (Scop.)			r
Eristalomyia tenax (L.)		xx	xx
Helophilus hybridus Loew.			r
H.pendulus (L.)	x	x	xx
H.trivittatus (Fabr.)	x	x	
Lasiopticus pyrastri (L.)			r
Melanostoma mellinum (L.)		x	x
Myiatropa florea (L.)	x		x
Pipiza festiva Meig.	x		
Sphaerophoria menthastri (L.)			x
Syritta pipiens (L.)			xx
Syrphus albostriatus (Fall.)			r
S.corollae Fabr.	x	x	
S.luniger Meig.		r	
S.ribesii (L.)	x	x	xx
S.tricinctus (Fall.)			r
S.vitripennis Meig.	x	xx	xx
Volucella pellucens (L.)		r	
V.zonaria (Poda)			r
Zelima segnis (L.)	r		
Species:	9	13	18

xx = dominant; x = abundant; r = rare.

more extensive studies in an English suburban garden, Owen (1978) found a total of 81 species, 47 of these in the first year of study.

Since we must assume that some species do not brood directly in the area, because their larvae have special needs, for example they live in water, the species number in the Sites II and III is relatively high for ruderal areas isolated in the middle of a city. This is probably due to the abundance of flowers. Site I is presumably thinly populated because of its greater isolation and the occurrence of fewer flowers. Eleven of the species found feed as larvae on leaf lice and other homoptera, and eight species require small muddy bodies of water. Several suitable bodies of water can be found in the vicinity of Site III, which probably explains why this group of the Syrphids is more abundant (39% of the total) than at other sites.

BUMBLE BEES (HYMENOPTERA, BOMBUS SPP.)

The species which exist in the three areas were determined on 10 catch dates each. Exact dominance numbers were not established. Only five species, which are frequent in the Berlin area, were found in the ruderal sites (Table 8.4). Cuckoo bees (*Psithyrus* spp.) were not observed.

TABLE 8.4. *Bumble bees in three ruderal areas in the city of Berlin.*

Site	I	II	III
Bombus agrorum (F.)		x	xx
B.hypnorum (L.)		xx	xx
B.lapidarius (L.)	r	xx	xx
B.pratorum (L.)			x
B.terrestris (L.)		x	xx
Species:	1	4	5

xx = dominant; x = abundant; r = rare.

Bumble bees do not fly very far from their nest, seldom more than 2 km. It can, therefore, be supposed that all species live in the study areas II and III or in the adjacent ruderal areas and in the 'Grosser Tiergarten'. The rubble soil, which is rich in openings, offers many nesting possibilities. Bumble bees are generally short of food sources and nesting sites in the built-up city area, but these ruderal sites are, for a large city, extremely rich in flowers and therefore have a high ecological value. Owen (1978) found eight Bombus spp. and two Psithyrus spp. in an English suburban garden.

DISCUSSION

All animal groups studied show the least number of species (total 18) at Site I.

which is the most isolated site from other green areas and lies in a heavily built-up section. All animal groups show the highest numbers of species (total 60) at Site III, which has direct contact to a large city park and to other ruderal sites. The ruderal meadow IIb has, with a total of 41 species, an average value; it is separated only by a canal from Site III, but is surrounded on the other sides by buildings.

It seems probable that, given a relatively similar vegetation development, the faunistic richness is decided by the position of potentially colonizable areas in relation to already colonized regions. In comparison to the easily colonized Site III (next to a park and in a former villa district), Site I harbours only 25% oribatid species, 20% carabid species, no *Bombus* spp. and 50% Syrphid species. The relatively high Syrphid figure relates to dispersal activity. In addition to the isolation from animal populations, Site I is also from a floristic standpoint the poorest, presumably also as a result of isolation. If one supposes, following the ideas of MacArthur and Wilson (1967), that 'biotope islands' in the city also strive for an equilibrium of species numbers, which depends on the size of the island as well as on the ecological variety, then Site I, as the smallest island, will presumably always remain relatively species-poor.

The non-flying brachypterous carabids and the dimorphic species (in part brachypterous) are particularly interesting for our discussion. *Calathus fuscipes* (b), which was dominant in Sites II and III, was very rare on Site I (only one animal was observed) and had possibly only arrived recently (?).

Haeck (1971) found 'almost exclusively winged individuals of dimorphic species' on newly formed polders in Holland. A similar observation does not appear to hold true for all dimorphic species of the 'biotope island' of Site I. All seven *C.melanocephalus* and two of three *C.mollis* individuals were brachypterous, but all 12 *C.piceus* were macropterous.

An empirical rule with regard to island carabids (see Barndt 1976, p. 51) seems, on the other hand, to be substantiated. This rule states that on islands, fewer brachypterous species but more dimorphic species with macropterous individuals occur than on the mainland.

At the isolated Site I, 13 of 22 individuals (59%) of the three dimorphic species were macropterous; at Site III, seven of 24 individuals (29%) of the five dimorphic species were macropterous.

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